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AFFDL-TR-66-178

THERMOCOUPLE REFERENCE TABLES

EDWIN M. CANDLER, JR.

TECHNICAL REPORT AFFDL-TR-66-178

MARCH 1967

AIR FORCE FLIGHT DYNAMICS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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100 - April 1967 - CO192 - 30-709

AFFDL-TR-66-178

THERMOCOUPLE REFERENCE TABLES

EDWIN M. CANDLER, JR.

FOREWORD

This report was prepared in the Data Acquisition Group, Structures Test Branch, Structures Division, of the Air Force Flight Dynamics Laboratory.

The work was accomplished by Mr. Edwin M. Candler, Instrumentation Project Engineer, in compliance with test support requirements for Project No. 1368, "Structural Design Concepts," Task No. 136804, "Re-Entry and Hyperthermantic Structures."

This technical report has been reviewed and is approved.

Robert L. Cavanagh

ROBERT L. CAVANAGH
Chief, Structures Test Branch
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ABSTRACT

This report consists of thermocouple reference tables covering the temperature range from -320°F to +4200°F. The tabular data are based upon a reference junction temperature of 150°F.

These tables reflect the temperature-EMF relationship for the following thermoelectric combinations: copper vs. constantan, iron vs. constantan, chromel vs. constantan, geminol-P vs. geminol-N, chromel vs. alumel, tungsten vs. tungsten 26% rhenium, tungsten 5% rhenium vs. tungsten 26% rhenium, platinum vs. platinum 10% rhodium, platinum vs. platinum 13% rhodium, platinum 6% rhodium vs. platinum 30% rhodium, iridium vs. tungsten, and iridium vs. iridium 40% rhodium.

The tables presented herein were prepared as a result of instrumentation requirements in support of Project 1368, Task 136804, "Re-Entry and Hyperthermantic Structures."

LIST OF SYMBOLS

Thermoelectric Combination		Abbreviation	Symbol Calibration
1.	Copper vs. Constantan	Cu/Const.	T
2.	Iron vs. Constantan	Fe/Const.	J
3.	Chromel vs. Constantan	Ch/Const.	E
4.	Geminol-P vs. Geminol-N*	Geminol P&N	P
5.	Chromel vs. Alumel*	Ch/Al	K
6.	Tungsten vs Tungsten 26% Rhenium	W/W26Re	B
7.	Tungsten 5% Rhenium vs. Tungsten 26% Rhenium	W5Re/W26Re	C
8.	Platinum vs. Platinum 10% Rhodium	Pt/Pt10Rh	S
9.	Platinum vs. Platinum 13% Rhodium	Pt/Pt13Rh	R
10.	Platinum 6% Rhodium vs. Platinum 30% Rhodium	Pt6Rh/Pt30Rh	X
11.	Iridium vs. Tungsten	Ir/W	F
12.	Iridium vs. Iridium 40% Rhodium	Ir/Ir40Rh	L

*Tradenames

INTRODUCTION

The tables presented herein have been compiled to make available, in composite and convenient form, data necessary to convert measured electromotive force (EMF) of thermocouples into equivalent temperatures.

These tables cover the temperature range from -320°F through +4200°F for the following thermoelectric combinations: copper vs. constantan, iron vs. constantan, chromel vs. constantan, geminol-P vs. geminol-N, chromel vs. alumel, tungsten vs. tungsten 26% rhenium, tungsten 5% rhenium vs. tungsten 26% rhenium, platinum vs. platinum 10% rhodium, platinum vs. platinum 13% rhodium, platinum 6% rhodium vs. platinum 30% rhodium, iridium vs. tungsten, and iridium vs. iridium 40% rhodium. The data presented for each of these combinations is based upon a reference junction temperature of 150°F.

The compilation of this report was directly resultant of (1) the AFFDL Structures Test Facility's use of 150°F temperature controlled reference junctions rather than 32°F reference junctions, and (2) test instrumentation requirements in support of Task No. 136804 which necessitated the use of thermoelectric combinations not yet calibrated by the National Bureau of Standards (NBS).

The combination of primary interest was iridium vs. iridium 40% rhodium. Because very little information between 75°F and 1800°F was found to be available relative to the EMF-Temperature relationship of this type thermocouple, an experimental comparative analysis was conducted by the writer to enable satisfaction of measurement requirements. Before the completion of the test program, however, NBS presented tabular data, based upon a 32°F reference junction temperature, which verified this writer's experimental data. The NBS data, which was more definitive and extensive, was used to define the relationship of EMF to temperature.

All tabular data presented, with the exception of data relative to the iridium vs. iridium 40% rhodium combination, are derived from "CON-O-CHART No. 1," Continental Sensing, Inc., revised October 1963. The iridium-rhodium data was derived from "Reference Tables for Thermocouples of Iridium-Rhodium Alloys vs. Iridium," Journal of Research, NBS, Vol. 68C, No. 1, January-March 1964.

The calibration codings used in this report are those of CON-O-CHART. These agree with Instrument Society of America (ISA) calibration symbols with the exception of chromel vs. constantan and those combinations not yet calibration coded by ISA.

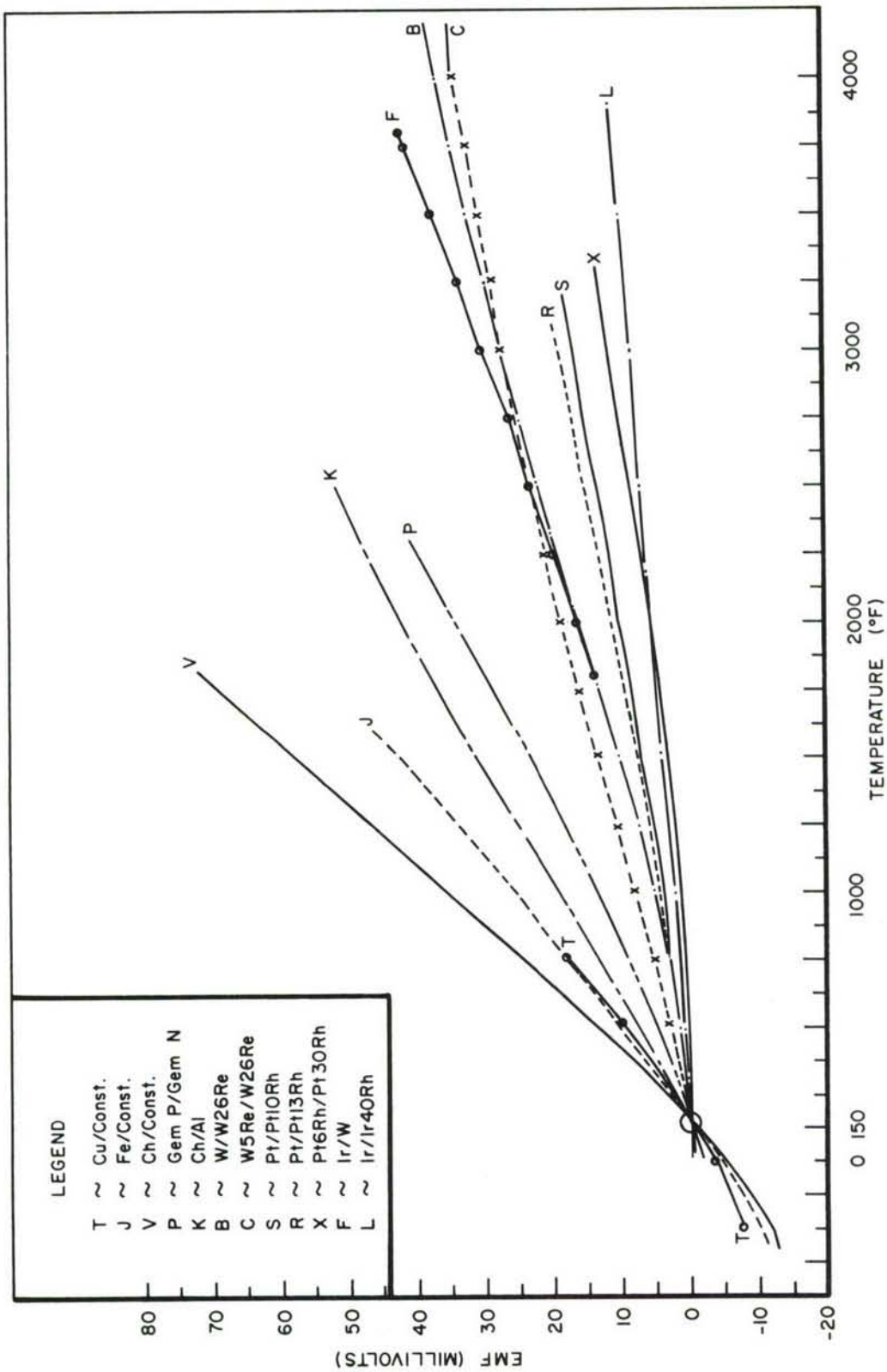

Figure 1. Thermocouple Temperature Vs. Millivolt Curves

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

-320°F to 10°F				
°F	T Cu/ Const.	E Ch/ Const.	J Fe/ Const.	K Ch/Al
-320		-12.64		-8.36
-310	-8.090	-12.49	-11.07	-8.26
-300	-7.995	-12.34	-10.93	-8.17
-290	-7.896	-12.18	-10.79	-8.07
-280	-7.792	-12.01	-10.63	-7.96
-270	-7.685	-11.84	-10.47	-7.86
-260	-7.574	-11.66	-10.30	-7.74
-250	-7.458	-11.48	-10.12	-7.62
-240	-7.338	-11.28	-9.94	-7.50
-230	-7.215	-11.08	-9.76	-7.37
-220	-7.088	-10.87	-9.57	-7.24
-210	-6.957	-10.66	-9.37	-7.10
-200	-6.822	-10.44	-9.17	-6.95
-190	-6.683	-10.22	-8.96	-6.81
-180	-6.540	-9.99	-8.75	-6.66
-170	-6.395	-9.76	-8.53	-6.50
-160	-6.244	-9.52	-8.31	-6.35
-150	-6.091	-9.27	-8.09	-6.18
-140	-5.934	-9.02	-7.85	-6.02
-130	-5.773	-8.77	-7.62	-5.85
-120	-5.608	-8.51	-7.38	-5.67
-110	-5.441	-8.25	-7.14	-5.49
-100	-5.270	-7.98	-6.90	-5.31
-90	-5.096	-7.71	-6.65	-5.13
-80	-4.918	-7.43	-6.40	-4.94
-70	-4.737	-7.15	-6.15	-4.75
-60	-4.553	-6.87	-5.89	-4.56
-50	-4.365	-6.58	-5.63	-4.36
-40	-4.174	-6.28	-5.37	-4.16
-30	-3.981	-5.98	-5.11	-3.96
-20	-3.783	-5.68	-4.84	-3.76
-10	-3.583	-5.37	-4.57	-3.55

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

MIL/VLTS 0°F to 300°F						
°F	T Cu/ Const.	(E) V Ch/ Const.	J Fe/ Const.	K Ch/Al	P Geminol P&N	B W/ W26RE
0	-3.381	-5.060	-4.300	-3.340		
10	-3.174	-4.750	-4.020	-3.130	-1.870	
20	-2.965	-4.430	-3.750	-2.920	-1.740	
30	-2.753	-4.110	-3.470	-2.700		
40	-2.540	-3.780	-3.190	-2.480	-1.480	-0.182
50	-2.322	-3.450	-2.910	-2.260	-1.340	
60	-2.102	-3.120	-2.620	-2.040	-1.210	-0.152
70	-1.879	-2.780	-2.340	-1.820	-1.080	
80	-1.654	-2.450	-2.050	-1.600	-0.950	-0.122
90	-1.425	-2.310	-1.760	-1.370	-0.810	
100	-1.194	-1.770	-1.470	-1.140	-0.680	-0.091
110	-0.960	-1.420	-1.180	-0.920	-0.540	
120	-0.724	-1.070	-0.890	-0.690	-0.410	-0.058
130	-0.485	-0.720	-0.590	-0.460	-0.270	
140	-0.244	-0.360	-0.300	-0.230	-0.140	-0.021
150	0.000	0.000	0.000	0.000	0.000	0.000
160	0.247	0.360	0.300	0.230	0.140	0.021
170	0.496	0.730	0.600	0.460	0.270	
180	0.747	1.090	0.900	0.700	0.410	0.070
190	1.001	1.460	1.200	0.900	0.540	
200	1.256	1.830	1.500	1.160	0.680	0.126
210	1.514	2.210	1.800	1.390	0.820	
220	1.775	2.580	2.100	1.620	0.960	0.190
230	2.038	2.960	2.400	1.850	1.100	
240	2.303	3.340	2.700	2.080	1.240	0.258
250	2.569	3.720	3.010	2.310	1.380	
260	2.839	4.110	3.310	2.540	1.520	0.328
270	3.110	4.500	3.620	2.760	1.660	
280	3.383	4.890	3.920	2.990	1.800	0.403
290	3.659	5.280	4.230	3.210	1.940	
300	3.936	5.670	4.530	3.430	2.080	0.479

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

0°F to 300°F					
°F	C W5Re/ W26Re	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh	L Ir/ Ir40Rh
0		-0.492	-0.494		-0.279
10		-0.464	-0.466		-0.265
20		-0.435	-0.437		-0.250
30		-0.406	-0.407	-0.030	-0.233
40	-0.849	-0.376	-0.377		-0.216
50		-0.345	-0.345	-0.028	-0.198
60	-0.701	-0.314	-0.314	-0.027	-0.180
70		-0.281	-0.281	-0.025	-0.162
80	-0.550	-0.248	-0.248	-0.023	-0.143
90		-0.214	-0.214	-0.020	-0.124
100	-0.396	-0.180	-0.180	-0.017	-0.104
110		-0.145	-0.145	-0.014	-0.084
120	-0.239	-0.109	-0.110	-0.011	-0.063
130		-0.073	-0.074	-0.007	-0.043
140	-0.080	-0.037	-0.037	-0.004	-0.021
150	0.000	0.000	0.000	0.000	0.000
160	0.080	0.038	0.038	0.004	0.022
170		0.076	0.076	0.008	0.044
180	0.241	0.176	0.175	0.012	0.067
190			0.184	0.016	0.089
200	0.404	0.196	0.194	0.021	0.112
210		0.237	0.234	0.025	0.136
220	0.569	0.278	0.275	0.030	0.160
230		0.321	0.316	0.035	0.184
240	0.736	0.363	0.357	0.040	0.208
250		0.407	0.399	0.045	0.233
260	0.905	0.450	0.442	0.050	0.258
270		0.494	0.485	0.055	0.283
280	1.076	0.539	0.518	0.060	0.308
290		0.584	0.572	0.065	0.334
300	1.249	0.630	0.616	0.071	0.360

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

300°F to 600°F						
°F	T Cu/ Const.	V Ch/ Const.	J Fe/ Const.	K Ch/Al	P Geminol P&N	B W/ W26Re
300	3.936	5.670	4.530	3.430	2.080	0.479
310	4.215	6.070	4.840	3.650	2.220	
320	4.497	6.470	5.150	3.870	2.350	0.556
330	4.780	6.870	5.460	4.100	2.500	
340	5.065	7.270	5.760	4.320	2.640	0.634
350	5.353	7.670	6.070	4.540	2.790	
360	5.641	8.070	6.380	4.750	2.930	0.712
370	5.931	8.480	6.690	4.980	3.070	
380	6.224	8.890	7.010	5.210	3.210	0.791
390	6.518	9,300	7.310	5.430	3.350	
400	6.814	9.710	7.620	5.650	3.490	0.870
410	7.112	10.130	7.930	5.880	3.640	
420	7.412	10.550	8.240	6.100	3.790	0.954
430	7.712	10.960	8.550	6.320	3.940	
440	8.015	11.380	8.850	6.550	4.090	1.052
450	8.319	11.800	9.160	6.770	4.240	
460	8.625	12.220	9.470	7.000	4.390	1.155
470	8.932	12.640	9.780	7.220	4.540	
480	9.242	13.060	10.090	7.450	4.690	1.264
490	9.552	13.480	10.400	7.680	4.840	
500	9.864	13.910	10.710	7.910	4.990	1.379
510	10.177	14.340	11.010	8.130	5.150	
520	10.492	14.770	11.320	8.360	5.310	1.498
530	10.809	15.190	11.630	8.590	5.470	
540	11.127	15.620	11.930	8.820	5.630	1.622
550	11.446	16.050	12.240	9.050	5.790	
560	11.766	16.480	12.550	9.280	5.940	1.750
570	12.088	16.910	12.850	9.510	6.100	
580	12.411	17.350	13.160	9.740	6.260	1.882
590	12.736	17.780	13.470	9.970	6.440	
600	13.062	18.210	13.770	10.200	6.600	2.018

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

300°F to 600°F					
°F	C W5Re/ W26Re	R Pt/ Pt/13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh	L Ir/ Ir40Rh
300	1.249	0.630	0.616	0.071	0.360
310		0.675	0.660	0.077	0.386
320	1.424	0.721	0.705	0.083	0.413
330		0.767	0.750	0.089	0.440
340	1.601	0.814	0.795	0.095	0.467
350		0.861	0.841	0.102	0.494
360	1.780	0.909	0.886	0.109	0.521
370		0.957	0.933	0.116	0.549
380	1.961	1.006	0.979	0.123	0.577
390		1.055	1.026	0.130	0.605
400	2.144	1.104	1.073	0.139	0.634
410		1.153	1.120	0.148	0.662
420	2.329	1.203	1.168	0.158	0.691
430		1.253	1.215	0.168	0.720
440	2.517	1.303	1.263	0.179	0.749
450		1.354	1.311	0.191	0.778
460	2.708	1.405	1.360	0.204	0.808
470		1.456	1.408	0.218	0.837
480	2.902	1.508	1.457	0.232	0.867
490		1.560	1.506	0.247	0.897
500	3.099	1.612	1.555	0.263	0.928
510		1.665	1.604	0.280	0.958
520	3.298	1.717	1.654	0.297	0.988
530		1.770	1.704	0.314	1.019
540	3.499	1.823	1.754	0.331	1.050
550		1.877	1.804	0.349	1.081
560	3.702	1.930	1.854	0.367	1.112
570		1.984	1.905	0.385	1.143
580	3.906	2.038	1.956	0.403	1.174
590		2.093	2.006	0.423	1.206
600	4.111	2.147	2.057	0.441	1.238

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

600°F to 900°F						
°F	T Cu/ Const.	V Ch/ Const.	J Fe/ Const.	K Ch/Al	P Geminol P&N	B W/ W26Re
600	13.062	18.210	13.770	10.200	6.600	2.018
610	13.390	18.650	14.080	10.430	6.780	
620	13.718	19.090	14.390	10.660	6.940	2.156
630	14.047	19.530	14.700	10.890	7.110	
640	14.378	19.960	15.000	11.120	7.270	2.298
650	14.710	20.400	15.310	11.360	7.470	
660	15.043	20.840	15.620	11.590	7.610	2.441
670	15.378	21.280	15.930	11.820	7.770	
680	15.714	21.720	16.230	12.050	7.940	2.585
690	16.050	22.160	16.540	12.290	8.100	
700	16.389	22.610	16.850	12.520	8.260	2.733
710	16.728	23.050	17.150	12.750	8.430	
720	17.068	23.490	17.460	12.990	8.600	2.885
730	17.409	23.930	17.770	13.220	8.780	
740	17.752	24.380	18.070	13.460	8.950	3.041
750	18.094	24.820	18.380	13.690	9.120	
760		25.270	18.690	13.930	9.290	3.199
770		25.710	18.990	14.160	9.460	
780		26.150	19.300	14.400	9.640	3.359
790		26.600	19.600	14.630	9.810	
800		27.050	19.910	14.870	9.980	3.522
810		27.500	20.220	15.100	10.160	
820		27.940	20.520	15.340	10.340	3.687
830		28.390	20.830	15.570	10.520	
840		28.830	21.140	15.810	10.700	3.855
850		29.280	21.440	16.400	10.880	
860		29.730	21.750	16.280	11.050	4.025
870		30.180	22.060	16.520	11.230	
880		30.630	22.370	16.750	11.410	4.197
890		31.080	22.680	16.990	11.590	
900		31.530	22.990	17.230	11.770	4.371

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

600°F to 900°F					
°F	C W5Re/ W26Re	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh	L Ir/ Ir40Rh
600	4.111	2.147	2.057	0.441	1.238
610		2.202	2.109	0.460	1.269
620	4.317	2.257	2.160	0.479	1.301
630		2.312	2.212	0.498	1.333
640	4.524	2.368	2.263	0.518	1.365
650		2.423	2.315	0.539	1.397
660	4.732	2.479	2.367	0.560	1.429
670		2.535	2.419	0.581	1.462
680	4.941	2.591	2.471	0.602	1.494
690		2.647	2.523	0.623	1.527
700	5.151	2.703	2.576	0.644	1.559
710		2.760	2.628	0.666	1.592
720	5.362	2.817	2.681	0.688	1.625
730		2.873	2.734	0.710	1.658
740	5.574	2.930	2.787	0.732	1.691
750		2.987	2.839	0.755	1.724
760	5.787	3.045	2.892	0.778	1.757
770		3.102	2.946	0.801	1.790
780	6.000	3.160	2.999	0.824	1.823
790		3.218	3.052	0.847	1.856
800	6.214	3.277	3.105	0.871	1.889
810		3.335	3.159	0.895	1.923
820	6.428	3.394	3.213	0.920	1.956
830		3.452	3.266	0.945	1.990
840	6.643	3.511	3.320	0.970	2.023
850		3.570	3.374	0.995	2.057
860	6.858	3.629	3.428	1.020	2.090
870		3.687	3.482	1.045	2.124
880	7.073	3.746	3.536	1.071	2.157
890		3.805	3.590	1.098	2.191
900	7.289	3.864	3.645	1.125	2.225

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

900°F to 1200°F						
°F	V Ch/ Const.	J Fe/ Const.	K Ch/Al	P Geminol P&N	B W/ W26Re	C W5Re/ W26Re
900	31.530	22.990	17.230	11.770	4.371	7.289
910	31.980	23.290	17.470	11.960		
920	32.430	23.610	17.700	12.140	4.547	7.505
930	32.880	23.920	17.940	12.330		
940	33.330	24.230	18.180	12.510	4.725	7.721
950	33.780	24.540	18.410	12.700		
960	34.220	24.850	18.650	12.880	4.906	7.937
970	34.670	25.170	18.880	13.070		
980	35.120	25.480	19.120	13.250	5.089	8.154
990	35.570	25.800	19.360	13.440		
1000	36.020	26.110	19.600	13.620	5.276	8.371
1010	36.470	26.430	19.830	13.810		
1020	36.920	26.750	20.070	14.000	5.466	8.588
1030	37.370	27.070	20.310	14.190		
1040	37.820	27.390	20.540	14.380	5.641	8.805
1050	38.270	27.710	20.780	14.580		
1060	38.720	28.030	21.020	14.770	5.849	9.022
1070	39.170	28.350	21.250	14.960		
1080	39.620	28.670	21.490	15.150	6.042	9.238
1090	40.070	28.990	21.730	15.340		
1100	40.520	29.310	21.970	15.530	6.236	9.454
1110	40.970	29.640	22.200	15.720		
1120	41.420	29.960	22.440	15.920	6.432	9.670
1130	41.870	30.290	22.680	16.110		
1140	42.320	30.620	22.910	16.310	6.632	9.885
1150	42.770	30.950	23.150	16.500		
1160	43.220	31.270	23.390	16.690	6.834	10.100
1170	43.670	31.600	23.620	16.890		
1180	44.110	31.940	23.860	17.080	7.038	10.315
1190	44.560	32.270	24.090	17.280		
1200	45.000	32.600	24.320	17.470	7.242	10.529

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

900°F to 1200°F				
°F	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh	L Ir/ Ir40Rh
900	3.864	3.645	1.125	2.225
910	3.924	3.699	1.153	2.258
920	3.984	3.754	1.181	2.292
930	4.043	3.809	1.209	2.326
940	4.103	3.863	1.237	2.359
950	4.163	3.918	1.266	2.393
960	4.224	3.973	1.295	2.427
970	4.285	4.029	1.324	2.461
980	4.346	4.084	1.353	2.495
990	4.407	4.139	1.383	2.528
1000	4.468	4.195	1.413	2.562
1010	4.530	4.250	1.443	2.596
1020	4.591	4.306	1.473	2.630
1030	4.653	4.362	1.504	2.664
1040	4.715	4.417	1.535	2.698
1050	4.776	4.473	1.566	2.732
1060	4.838	4.529	1.598	2.766
1070	4.901	4.586	1.630	2.800
1080	4.963	4.642	1.662	2.834
1090	5.026	4.698	1.694	2.868
1100	5.088	4.755	1.726	2.902
1110	5.151	4.811	1.759	2.936
1120	5.214	4.868	1.792	2.970
1130	5.277	4.925	1.826	3.003
1140	5.341	4.982	1.860	3.037
1150	5.405	5.039	1.894	3.071
1160	5.469	5.096	1.928	3.105
1170	5.533	5.154	1.963	3.138
1180	5.596	5.211	1.998	3.172
1190	5.660	5.268	2.033	3.205
1200	5.725	5.325	2.068	3.239

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

1200°F to 1500°F						
°F	V Ch/ Const.	J Fe/ Const.	K Ch/Al	P Geminol P&N	B W/ W26Re	C W5Re/ W26Re
1200	45.000	32.600	24.320	17.470	7.242	10.529
1210	45.450	32.940	24.560	17.670		
1220	45.890	33.280	24.790	17.870	7.447	10.743
1230	46.330	33.610	25.030	18.070		
1240	46.780	33.950	25.260	17.270	7.654	10.957
1250	47.230	34.300	25.490	18.480		
1260	47.680	34.640	25.730	18.680	7.863	11.170
1270	48.120	34.980	25.960	18.880		
1280	48.570	35.330	26.200	19.080	8.074	11.383
1290	49.010	35.670	26.430	19.280		
1300	49.460	36.020	26.660	19.480	8.287	11.596
1310	49.900	36.370	26.900	19.680		
1320	50.340	36.720	27.130	19.890	8.502	11.809
1330	50.790	37.070	27.360	20.090		
1340	51.230	37.420	27.590	20.300	8.719	12.021
1350	51.670	37.780	27.830	20.500		
1360	52.110	38.130	28.060	20.700	8.938	12.233
1370	52.550	38.490	28.290	20.910		
1380	52.990	38.840	28.520	21.110	9.159	12.445
1390	53.440	39.200	28.760	21.320		
1400	53.880	39.550	28.990	21.520	9.382	12.657
1410	54.320	39.910	29.220	21.730		
1420	54.760	40.270	29.450	21.940	9.606	12.868
1430	55.200	40.620	29.680	22.150		
1440	55.640	40.980	29.910	22.360	9.831	13.079
1450	56.070	41.340	30.140	22.570		
1460	56.510	41.690	30.360	22.780	10.056	13.290
1470	56.950	42.050	30.590	22.990		
1480	57.390	42.410	30.820	23.200	10.282	13.501
1490	57.820	42.770	31.050	23.410		
1500	58.260	43.120	31.270	23.620	10.508	13.711

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

1200°F to 1500°F				
°F	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh	L Ir/ Ir40Rh
1200	5.725	5.325	2.068	3.239
1210	5.788	5.383	2.104	3.272
1220	5.852	5.441	2.140	3.306
1230	5.917	5.498	2.240	3.339
1240	5.918	5.560	2.214	3.373
1250	6.046	5.614	2.251	3.406
1260	6.111	5.672	2.288	3.439
1270	6.177	5.730	2.326	3.473
1280	6.242	5.789	2.365	3.506
1290	6.307	5.847	2.404	3.539
1300	6.373	5.906	2.433	3.572
1310	6.438	5.964	2.482	3.605
1320	6.504	6.023	2.521	3.639
1330	6.570	6.082	2.560	3.672
1340	6.637	6.141	2.599	3.705
1350	6.703	6.200	2.638	3.737
1360	6.769	6.259	2.677	3.770
1370	6.835	6.318	2.717	3.803
1380	6.902	6.377	2.757	3.836
1390	6.969	6.437	2.797	3.869
1400	7.036	6.496	2.837	3.901
1410	7.103	6.556	2.877	3.934
1420	7.171	6.616	2.917	3.967
1430	7.239	6.675	2.958	3.999
1440	7.306	6.735	2.999	4.032
1450	7.374	6.795	3.040	4.064
1460	7.442	6.856	3.081	4.097
1470	7.511	6.916	3.123	4.129
1480	7.579	6.976	3.165	4.161
1490	7.647	7.037	3.208	4.193
1500	7.716	7.097	3.251	4.226

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

1500°F to 1800°F						
°F	V Ch/ Const.	J Fe/ Const.	K Ch/Al	P Geminol P&N	F Ir*	B W/ W26Re
1500	58.260	43.120	31.270	23.620		10.508
1510	58.700	43.480	31.500	23.830		
1520	59.130	43.830	31.730	24.040		10.734
1530	59.560	44.190	31.960	24.250		
1540	60.000	44.540	32.180	24.460		10.961
1550	60.430	44.900	32.410	24.670		
1560	60.860	45.250	32.630	24.880		11.188
1570	61.300	45.600	32.860	25.090		
1580	61.730	45.950	33.090	25.300		11.415
1590	62.160	46.290	33.310	25.510		
1600	62.590	46.640	33.530	25.720		11.643
1610	63.010		33.760	25.940		
1620	63.440		33.980	26.150		11.871
1630	63.870		34.210	26.370		
1640	64.300		34.430	26.580		12.100
1650	64.720		34.650	26.800		
1660	65.150		34.800	27.020		12.329
1670	65.580		35.100	27.230		
1680	66.010		35.320	27.450		12.559
1690	66.430		35.540	27.660		
1700	66.860		35.770	27.880		12.790
1710	67.280		35.990	28.100		
1720	67.710		36.210	28.320		13.021
1730	68.130		36.430	28.540		
1740	68.560		36.650	28.760		13.253
1750	68.980		36.870	28.980		
1760	69.400		37.090	29.190		13.486
1770	69.820		37.300	29.410		
1780	70.240		37.520	29.630		13.720
1790	70.660		37.740	29.850		
1800	71.080		37.960	30.070	13.910	13.955

*Ir/W Temperature vs EMF data is a result of extrapolation from 32°F reference junction data.

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

1500°F to 1800°F					
°F	C W5Re/ W26Re	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh	L Ir/ Ir40Rh
1500	13.711	7.716	7.097	3.251	4.226
1510		7.784	7.158	3.294	4.258
1520	13.921	7.853	7.219	3.337	4.290
1530		7.922	7.280	3.380	4.322
1540	14.131	7.991	7.341	3.424	4.354
1550		8.060	7.402	3.468	4.386
1560	14.341	8.130	7.463	3.512	4.418
1570		8.199	7.524	3.557	4.450
1580	14.550	8.269	7.586	3.602	4.481
1590		8.339	7.647	3.648	4.513
1600	14.759	8.409	7.709	3.694	4.545
1610		8.479	7.771	3.740	4.576
1620	14.968	8.549	7.833	3.786	4.608
1630		8.619	7.895	3.832	4.639
1640	15.177	8.690	7.957	3.878	4.671
1650		8.761	8.019	3.924	4.702
1660	15.385	8.832	8.081	3.970	4.734
1670		8.903	8.144	4.016	4.765
1680	15.593	8.974	8.206	4.063	4.796
1690		9.045	8.269	4.110	4.827
1700	15.801	9.116	8.331	4.157	4.859
1710		9.187	9.394	4.214	4.890
1720	16.009	9.259	8.457	4.252	4.921
1730		9.330	8.520	4.300	4.952
1740	16.216	9.402	8.583	4.349	4.983
1750		9.474	8.647	4.398	5.014
1760	16.423	9.546	8.710	4.447	5.044
1770		9.619	8.773	4.496	5.075
1780	16.630	9.692	8.837	4.545	5.106
1790		9.764	8.901	4.595	5.137
1800	16.836	9.837	8.964	4.645	5.167

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

1800°F to 2100°F						
°F	V Ch/ Const.	K Ch/Al	P Geminol P&N	F Ir/W	B W/ W26Re	C W5Re/ W26Re
1800	71.080	37.960	30.070	13.910	13.955	16.836
1810	71.690	38.180	30.290			
1820	71.910	38.390	30.510	14.170	14.191	17.042
1830	72.330	38.610	30.730			
1840		38.830	30.950	14.430	14.428	17.248
1850		39.040	31.180			
1860		39.260	31.400	14.680	14.666	17.453
1870		39.480	31.620			
1880		39.690	31.840	14.940	14.905	17.658
1890		39.910	32.060			
1900		40.120	32.280	15.200	15.145	17.826
1910		40.330	32.500			
1920		40.550	32.720	15.460	15.386	18.066
1930		40.760	32.950			
1940		40.970	33.170	15.700	15.628	18.269
1950		41.190	33.390			
1960		41.400	33.610	15.980	15.870	18.471
1970		41.610	33.830			
1980		41.830	34.060	16.240	16.113	18.672
1990		42.040	34.280			
2000		42.250	34.500	16.500	16.355	18.872
2010		42.460	34.720			
2020		42.670	34.950	16.760	16.597	19.071
2030		42.880	35.170			
2040		43.090	35.400	17.020	16.839	19.269
2050		43.300	35.620			
2060		43.510	35.840	17.290	17.080	19.466
2070		43.720	36.070			
2080		43.920	36.290	17.550	17.321	19.662
2090		44.130	36.520			
2100		44.340	36.740	17.810	17.561	19.857

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

1800°F to 2100°F				
°F	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh	L Ir/ Ir40Rh
1800	9.837	8.964	4.645	5.167
1810	9.910	9.028	4.696	5.198
1820	9.983	9.092	4.747	5.228
1830	10.056	9.156	4.798	5.279
1840	10.129	9.220	4.849	5.289
1850	10.203	9.285	4.900	5.320
1860	10.276	9.349	4.952	5.350
1870	10.349	9.414	5.004	5.380
1880	10.423	9.478	5.056	5.411
1890	10.498	9.543	5.108	5.441
1900	10.573	9.608	5.160	5.471
1910	10.648	9.673	5.212	5.501
1920	10.722	9.738	5.265	5.531
1930	10.797	9.803	5.318	5.561
1940	10.873	9.868	5.371	5.591
1950	10.948	9.933	5.425	5.621
1960	11.024	9.999	5.479	5.651
1970	11.099	10.064	5.533	5.681
1980	11.175	10.130	5.587	5.711
1990	11.251	10.196	5.641	5.740
2000	11.326	10.261	5.695	5.770
2010	11.402	10.327	5.749	5.800
2020	11.478	10.393	5.804	5.829
2030	11.554	10.459	5.859	5.859
2040	11.629	10.525	5.914	5.888
2050	11.705	10.591	5.969	5.918
2060	11.782	10.657	6.025	5.947
2070	11.858	10.723	6.081	5.977
2080	11.935	10.789	6.137	6.006
2090	12.011	10.856	6.193	6.035
2100	12.088	10.922	6.250	6.065

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

2100°F to 2400°F					
°F	K Ch/Al	P Geminol P&N	F Ir/W	B W/ W26Re	C W5Re/ W26Re
2100	44.340	36.740	17.810	17.561	19.857
2110	44.550	36.960			
2120	44.750	37.180	18.080	17.800	20.051
2130	44.960	37.410			
2140	45.160	37.630	18.350	18.038	20.244
2150	45.370	37.850			
2160	45.570	38.070	18.610	18.275	20.436
2170	45.780	38.290			
2180	45.980	38.520	18.880	18.511	20.627
2190	46.190	38.740			
2200	46.390	38.960	19.150	18.746	20.817
2210	46.590	39.180			
2220	46.790	39.400	19.420	18.981	21.006
2230	46.990	39.630			
2240	47.200	39.850	19.680	19.216	21.194
2250	47.400	40.070			
2260	47.600	40.290	19.950	19.451	21.381
2270	47.800	40.510			
2280	47.990	40.740	20.210	19.685	21.567
2290	48.190	40.960			
2300	48.390	41.180	20.480	19.919	21.752
2310	48.590				
2320	48.790		20.750	20.153	21.936
2330	48.980				
2340	49.180		21.020	20.387	22.119
2350	49.370				
2360	49.570		21.290	20.620	22.301
2370	49.760				
2380	49.960		21.560	20.853	22.483
2390	50.150				
2400	50.350		21.830	21.086	22.664

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

2100°F to 2400°F				
°F	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh	L Ir/ Ir40Rh
2100	12.088	10.922	6.250	6.065
2110	12.164	10.980	6.307	6.094
2120	12.241	11.055	6.364	6.123
2130	12.318	11.121	6.421	6.152
2140	12.395	11.188	6.479	6.182
2150	12.471	11.254	6.537	6.211
2160	12.548	11.321	6.595	6.240
2170	12.625	11.388	6.653	6.269
2180	12.702	11.454	6.711	6.298
2190	12.778	11.521	6.769	6.327
2200	12.855	11.588	6.827	6.356
2210	12.932	11.654	6.886	6.385
2220	13.009	11.788	6.945	6.414
2230	13.086	11.788	7.004	6.442
2240	13.164	11.855	7.063	6.471
2250	13.241	11.921	7.122	6.500
2260	13.318	11.988	7.182	6.529
2270	13.395	12.055	7.242	6.558
2280	13.472	12.122	7.302	6.586
2290	13.549	12.189	7.362	6.615
2300	13.627	12.256	7.422	6.644
2310	13.704	12.323	7.482	6.672
2320	13.781	12.389	7.542	6.701
2330	13.858	12.456	7.603	6.729
2340	13.935	12.523	7.664	6.758
2350	14.012	12.590	7.725	6.787
2360	14.090	12.657	7.786	6.815
2370	14.167	12.723	7.847	6.844
2380	14.244	12.790	7.908	6.872
2390	14.321	12.857	7.969	6.901
2400	14.398	12.924	8.030	6.929

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

2400°F to 2700°F						
°F	F Ir/W	B W/ W26Re	C W5Re/ W26Re	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh
2400	21.830	21.086	22.664	14.398	12.924	8.030
2410				14.475	12.990	8.091
2420	22.100	21.318	22.845	14.592	13.057	8.152
2430				14.629	13.124	8.213
2440	22.380	21.548	23.025	14.707	13.190	8.275
2450				14.784	13.257	8.337
2460	22.650	21.776	23.205	14.861	13.324	8.399
2470				14.938	13.390	8.461
2480	22.930	22.004	23.384	15.015	13.457	8.523
2490				15.092	13.523	8.585
2500	23.200	22.230	23.563	15.168	13.590	8.647
2510				15.245	13.657	8.709
2520	23.470	22.455	23.741	15.322	13.723	8.771
2530				15.400	13.790	8.833
2540	23.750	22.678	23.919	15.477	13.856	8.895
2550				15.554	13.923	8.957
2560	24.020	22.899	24.096	15.631	13.989	9.020
2570				15.708	14.056	9.083
2580	24.300	23.118	24.273	15.785	14.122	9.146
2590				15.863	14.188	9.209
2600	24.570	23.335	24.449	15.940	14.255	9.272
2610				16.017	14.321	9.334
2620	24.850	23.550	24.625	16.094	14.388	9.396
2630				16.171	14.454	9.459
2640	25.130	23.763	24.799	16.248	14.520	9.522
2650				16.325	14.587	9.585
2680	25.400	23.975	24.971	16.402	14.653	9.648
2670				16.480	14.719	9.710
2680	25,680	24.185	25.141	16.557	14.785	9.773
2690				16.633	14.852	9.836
2700	25.960	24.393	25.309	16.710	14.918	9.899

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

2400°F to 2700°F		
°F	L Ir/Ir40Rh	K Ch/Al
2400	6.929	50.350
2410	6.958	50.540
2420	6.986	50.730
2430	7.014	50.930
2440	7.043	51.120
2450	7.071	51.310
2460	7.100	51.500
2470	7.128	51.690
2480	7.156	51.880
2490	7.185	52.070
2500	7.213	
2510	7.241	
2520	7.269	
2530	7.298	
2540	7.326	
2550	7.354	
2560	7.383	
2570	7.411	
2580	7.439	
2590	7.467	
2600	7.496	
2610	7.524	
2620	7.552	
2630	7.580	
2640	7.609	
2650	7.637	
2660	7.665	
2670	7.693	
2680	7.722	
2690	7.750	
2700	7.778	

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

2700°F to 3000°F						
°F	F Ir/W	B W/ W26Re	C W5Re/ W26Re	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh
2700	25.960	24.393	25.309	16.710	14.918	9.899
2710				16.786	14.984	9.961
2720	26.240	24.600	25.475	16.863	15.050	10.024
2730				16.940	15.116	10.087
2740	26.520	24.806	25.639	17.016	15.182	10.150
2750				17.093	15.248	10.213
2760	26.790	25.012	25.801	17.169	15.314	10.275
2770				17.246	15.380	10.338
2780	27.070	25.217	25.961	17.323	15.447	10.401
2790				17.399	15.512	10.464
2800	27.350	25.422	26.119	17.475	15.578	10.526
2810				17.551	15.644	10.589
2820	27.630	25.627	26.275	17.627	15.710	10.652
2830				17.703	15.776	10.715
2840	27.910	25.832	26.430	17.779	15.842	10.778
2850				17.885	15.907	10.840
2860	28.190	26.036	26.584	17.932	15.973	10.903
2870				18.008	16.039	10.966
2880	28.470	26.239	26.737	18.084	16.105	11.029
2890				18.160	16.170	11.091
2900	28.750	26.442	26.889	18.236	16.236	11.154
2910				18.312	16.301	11.217
2920	29.030	26.645	27.040	18.388	16.367	11.280
2930				18.464	16.433	11.343
2940	29.320	26.847	27.190	18.540	16.498	11.405
2950				18.616	16.564	11.458
2960	29.600	27.049	27.339	18.692	16.629	11.531
2970				18.768	16.694	11.594
2980	29.890	27.251	27.487	18.843	16.760	11.656
2990				18.918	16.825	11.719
3000	30.170	27.452	27.634	18.994	16.891	11.782

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

2700°F to 3000°F	
°F	L Ir/ Ir40Rh
2700	7.778
2710	7.807
2720	7.835
2730	7.863
2740	7.891
2750	7.920
2760	7.948
2770	7.976
2780	8.005
2790	8.033
2800	8.061
2810	8.090
2820	8.118
2830	8.147
2840	8.175
2850	8.203
2860	8.232
2870	8.260
2880	8.289
2890	8.317
2900	8.346
2910	8.374
2920	8.403
2930	8.432
2940	8.460
2950	8.489
2960	8.517
2970	8.546
2980	8.575
2990	8.604
3000	8.632

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

3000°F to 3300°F						
°F	F Ir/W	B W/ W26Re	C W5Re/ W26Re	R Pt/ Pt13Rh	S Pt/ Pt10Rh	X Pt6Rh/ Pt30Rh
3000	30.170	27.452	27.634	18.994	16.891	11.782
3010				19.070	16.956	11.845
3020	30.460	27.653	27.780	19.145	17.021	11.908
3030				19.221	17.086	11.970
3040	30.740	27.854	27.926	19.297	17.151	12.033
3050				19.373	17.217	12.096
3060	31.030	28.055	28.071	19.448	17.282	12.159
3070				19.524	17.347	12.221
3080	31.310	28.255	28.216	19.599	17.412	12.284
3090				19.675	17.477	12.347
3100	31.600	28.455	28.360		17.542	12.410
3110					17.607	12.473
3120	31.890	28.654	28.502		17.672	12.535
3130					17.736	12.598
3140	32.180	28.853	28.644		17.801	12.661
3150					17.866	12.724
3160	32.460	29.051	28.786		17.931	12.786
3170					17.995	12.849
3180	32.750	29.249	28.928		18.060	12.912
3190					18.125	12.975
3200	33.040	29.446	29.070		18.190	13.038
3210					18.255	13.100
3220	33.330	29.644	29.211			13.163
3230						13.226
3240	33.620	29.842	29.352			13.289
3250						13.351
3260	33.910	30.039	29.493			13.413
3270						13.475
3280	34.200	30.236	29.634			
3290						
3300	34.490	30.433	29.775			

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

3000°F to 3300°F	
°F	L Ir/Ir40Rh
3000	8.632
3010	8.661
3020	8.690
3030	8.719
3040	8.748
3050	8.776
3060	8.805
3070	8.834
3080	8.863
3090	8.892
3100	8.921
3110	8.950
3120	8.980
3130	9.009
3140	9.038
3150	9.067
3160	9.096
3170	9.126
3180	9.155
3190	9.184
3200	9.214
3210	9.243
3220	9.273
3230	9.320
3240	9.332
3250	9.361
3260	9.391
3270	9.420
3280	9.450
3290	9.480
3300	9.510

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

3300°F to 3600°F				
°F	F Ir/W	B W/W26Re	C W5Re/W26Re	L Ir/Ir40Rh
3300	34.490	30.433	29.770	9.510
3310				9.539
3320	34.780	30.630	29.916	9.569
3330				9.599
3340	35.080	30.826	30.056	9.629
3350				9.659
3360	35.370	31.022	30.196	9.689
3370				9.719
3380	35.670	31.217	30.336	9.749
3390				9.780
3400	35.960	31.412	30.475	9.810
3410				9.840
3420	36.260	31.607	30.614	9.870
3430				9.901
3440	36.550	31.801	30.753	9.931
3450				9.961
3460	36.850	31.995	30.891	9.992
3470				10.022
3480	37.140	32.189	31.029	10.053
3490				10.084
3500	37.440	32.381	31.167	10.114
3510				10.145
3520	37.740	32.573	31.304	10.176
3530				10.206
3540	38.040	32.765	31.441	10.237
3550				10.268
3560	38.330	32.956	31.578	10.299
3570				10.330
3580	38.630	33.147	31.714	10.361
3590				10.392
3600	38.930	33.337	31.850	10.423

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F)

3600°F to 3900°F				
°F	F Ir/W	B W/W26Re	C W5Re/W26Re	L Ir/Ir40Rh
3600	38.930	33.337	31.850	10.423
3610				10.454
3620	39.230	33.527	31.986	10.485
3630				10.517
3640	39.530	33.717	32.121	10.548
3650				10.579
3660	39.830	33.906	32.256	10.611
3670				10.642
3680	40.130	34.095	32.391	10.674
3690				10.705
3700	40.430	34.283	32.525	10.737
3710				10.768
3720	40.730	34.471	32.659	10.800
3730				10.831
3740	41.030	34.658	32.792	10.863
3750				10.895
3760	41.330	34.845	32.924	10.927
3770				10.959
3780	41.620	35.032	33.055	10.990
3790				11.022
3800	41.930	35.218	33.185	11.054
3810				11.086
3820		35.404	33.314	11.118
3830				11.150
3840		35.590	33.442	11.183
3850				11.215
3860		35.775	33.569	11.247
3870				11.279
3880		35.960	33.695	11.311
3890				11.344
3900		36.144	33.820	11.376

THERMOCOUPLE TEMPERATURE VS. MILLIVOLT TABLES

(Reference Junction Temperature: 150°F

3900°F to 4200°F		
°F	B W/ W26Re	C W5Re/ W26Re
3900	36.144	33.820
3920	36.326	33.944
3940	36.505	34.067
3960	36.680	34.188
3980	36.850	34.307
4000	37.015	34.424
4020	37.175	34.539
4040	37.329	34.652
4060	37.475	34.762
4080	37.610	34.872
4100	37.732	34.979
4120	37.846	35.084
4140	37.957	35.187
4160	38.066	35.288
4180	38.174	35.387
4200	38.280	35.483

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1. ORIGINATING ACTIVITY *(Corporate author)*
Structures Test Branch
Structures Division
AF Flight Dynamics Laboratory

2a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

2b. GROUP

3. REPORT TITLE
THERMOCOUPLE REFERENCE TABLES

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Type of Report: Summary Inclusive Dates: June 1965 through December 1965

5. AUTHOR(S) *(Last name, first name, initial)*
CANDLER, EDWIN, M., JR.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1967	34	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 1368	AFFDL-TR-66-178
c. Task No. 136804	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

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13. ABSTRACT

This report consists of thermocouple reference tables covering the temperature range from -320°F to +4200°F. The tabular data are based upon a reference junction temperature of 150°F.

These tables reflect the temperature-EMF relationship for the following thermoelectric combinations: copper vs. constantan, iron vs. constantan, chromel vs. constantan, geminol-P vs. geminol-N, chromel vs. alumel, tungsten vs. tungsten 26% rhenium, tungsten 5% rhenium vs. tungsten 26% rhenium, platinum vs. platinum 10% rhodium, platinum vs. platinum 13% rhodium, platinum 6% rhodium vs. platinum 30% rhodium, iridium vs. tungsten, and iridium vs. iridium 40% rhodium.

The tables presented herein were prepared as a result of instrumentation requirements in support of Project 1368, Task 136804, "Re-Entry and Hyperthermantic Structures."

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